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RADIOLOGICAL SAFETY IN GAMMA SCAN PROCEDURES

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ABSTRACT

The distillation columns are considered as one of the most critical components in oil refineries, installations for processing of gases and chemical plants. The performance of the industrial plant depends on the ability of these columns to work as they were projected. The gamma scanning technology has been applied on the examinations of these process columns routinely. The process monitoring performance and efficiency is carried out by staff highly specialized and well trained, technologists and engineers of the technological evaluation group from TRICOM and the Radiation Technology Center, at IPEN/CNEN-SP. The column scan technology applies a radioactive source of cobalt-60, which emits gamma radiation. The intensity of the sealed source is much reduced, when compared with others non-destructive testing diagnosis techniques. The source holder is projected with radiological security characteristics to assure that the exposition for the group of inspection, staff of the plant operation and the public does not exceed the permissible limits recommended by the regulatory authority – Brazilian Nuclear Energy Commission - CNEN, as well as for the local procedures at the company. The aim of this paper is to present the involved aspects of radiological safety in performance tasks carried out by the technological evaluation group, which applies the gamma scanning technology in Brazil.

1. INTRODUCTION

Petrochemical and chemical process industries are the main users and beneficiaries of the radioisotope technology. Radioisotope techniques are very competitive and are largely applied for troubleshooting and process analysis of technically complex, continuously operating industrial plants. The success of these applications is attributed to their unique ability to provide information which otherwise cannot be obtained by alternate techniques [1].

Gamma scanning of columns, vessels and pipes is one of the major radioisotope sealed source technique. This largely used technique to obtain a clear inside view of processing equipment for process troubleshooting without the extensive costs of a shutdown. These are most useful on-line and non-invasive techniques to troubleshoot and optimize unit performance.

Gamma scanning technology has been applied on the examinations of process columns routinely. In oil refineries, installations for processing of gases and chemical plants, the distillation columns are considered as one of the most critical components. Figure 1 shows typical distillation columns. The performance of the industrial plant depends on the ability of these columns to work as they were projected.

Figure 1. Distillation columns in chemical plant.

A gamma scan is a cost effective solution to many refinery problems, chemical and gas plants. When scanning a distillation column or a similar vessel, deductions can be made regarding possible mechanical damage of trays inside the unit, as well as, regard to certain operational conditions in the unit, such as flooding, blockages, weeping and other process anomalies. On the other hand, the process and maintenance engineers can use the results from a gamma scan to verify theories, eliminate scenarios or introduce previously unknown possibilities in distillation column troubleshooting.

The aim of this paper is to present the involved aspects of radiological safety in performance tasks carried out by the technological evaluation group, which applies the gamma scanning technology in Brazil.

2. GAMMA SCANNING OF DISTILLATION COLUMNS

Gamma scanning of columns, also known as column scanning or tower scanning is a reliable and safe method of characterizing operating conditions in a column. It is a method of viewing the process fluids, which is non-invasive to the process and equipment.

The column scanning technology applies radioactive sources with high energy gamma-rays from cobalt-60 or cesium-137, which emit gamma radiation. The activity of the sealed source

is much reduced, when compared with other non-destructive testing diagnosis techniques. When scanning a distillation column, a small suitably sealed gamma radiation source and a radiation detector [NaI(Tl)] are moved concurrently in small increments on opposite sides, along the exterior length of the vessel and does no require any preparation by plant personnel.
A relative density profile of the column contents is thus obtained. Areas containing relatively high density material (such as liquid and/or metal) provide a relatively low intensity of transmitted radiation, while areas of relatively low density (vapors spaces between trays) result in a high intensity level.

The source holder is also projected with radiological security characteristics to assure that the radiation exposures for the inspection group, plant operation staff and public people do not exceed these permissible limits recommended by the regulatory authority – Brazilian Nuclear Energy Commission – CNEN, as well as for the local procedures at the company [2].

2.1. Column Examination

The process monitoring, work performance and production efficiency are evaluated applying gamma scanning technology. This nondestructive testing (NDT) also called nondestructive evaluation (NDE) and nondestructive inspection (NDI) is carried out by staff highly specialized and well trained, such as the technologists and engineers of the technological evaluation group from TRICOM and the Radiation Technology Center, at IPEN/CNEN-SP.

Comparing column mechanical drawings with relative density (gamma absorption) profile, a number of common malfunctions in trayed or packed columns can readily be determined. Some of which are summarized in the Table 1 [3].

Table 1. Common malfunctions in columns.

Column Problems	Malfunction Descriptions
Mechanical	▪ Displaced or damaged trays, demister pads and packing; ▪ Corrosion resulting in partial tray damage; ▪ Missing, collapsed or buckled trays or manways; ▪ Out-of-place liquid or vapor distributors; ▪ Level control problems on chimney trays or base liquid level.
Flow Rate	▪ Entrainment-slight, moderate, severe, jet flooding; ▪ Weeping or dumping trays; ▪ Dry or flooded trays due to loading conditions; ▪ Unequal liquid levels on trays and in parting boxes, troughs and collectors.
Process	▪ Foaming on trays or in reboilers, condensers and accumulators; ▪ Bad distribution of vapor and liquid in packing; ▪ Liquid hold-up due to plugging and fouling; ▪ Superheated or subcooled feed or reflux.

2.1.1. Radiological Safety Aspects

Column scan procedures use sealed radioactive sources, which emit gamma radiation. The source holders are designed with in-built radiological safety features to ensure that maximum effective dose for the inspection team (20 mSv/year), plant operation staff and public people (1 mSv/year) do not exceed these permissible limits recommended by the regulatory authority, Brazilian Nuclear Energy Commission – CNEN [2].

The practical parameters on radiation protection for gamma scan procedures are time, distance, shielding and prevention of radioactive source access, when it is positioned along the exterior length of the distillation column. Radioactive facility in operation should have in place an effective program for monitoring occupational exposure to radiation of these employees.

The use of portable gauges can present additional hazards if they are not used safely. It is not possible to utilize interlocked shutters to shield the radioactive source and, therefore, care must be taken to avoid irradiate people when the primary beam is exposed [4]. Prevention of source access may be not always possible by using physical barriers. So other means must be used, such as establishment of a controlled area, use of portable barriers and suitable warning notices.

3. RESULTS AND DISCUSSIONS

Prior to starting the gamma scan procedures, the inspection group had always needed a safe work permission from the petrochemical or chemical company, to access the platform top with specifics equipment, sealed source and mechanical drawings of the distillation column.

The restrict area for gamma scanning experiment was calculated by equation (1), took into account the limits recommended by the regulatory authority:

$$H = \frac{\Gamma . A}{d^2} \tag{1}$$

Where,

H: perimeter dose rate (μSv/h);
Γ: gamma-ray constant for specific source (μSv.m^2/GBq.h);
A: sealed source activity (GBq) and
d: restrict distance from the column (m).

The Figure 2 shows typical scanning profiles of distillation columns carried out in petrochemical and chemical companies by the technologists and engineers of the

technological evaluation group from TRICOM and the Radiation Technology Center, at IPEN/CNEN-SP. The results of the gamma scanning applying cobalt-60 sealed sources (activities from 0.5 GBq to 6.5 GBq) could be immediately discussed with process engineers so that they had always taken actions to optimize the columns performance.

The individual effective dose for the inspection team, after each gamma scan procedure had not exceed 10 µSv; measured by calibrated and digital display electronic pocket dosimeters made by Aloka, model PDM-273, gamma energy response above 20 keV and range from 1.0 µSv to 9,999 µSv. The radioprotection officer at IPEN/CNEN-SP had also used a calibrated Geiger-Müller radiation detector; model 6150 ADS, made by Automess, with dose rate measurement from 0.1 µSv/h to 1.0 Sv/h.

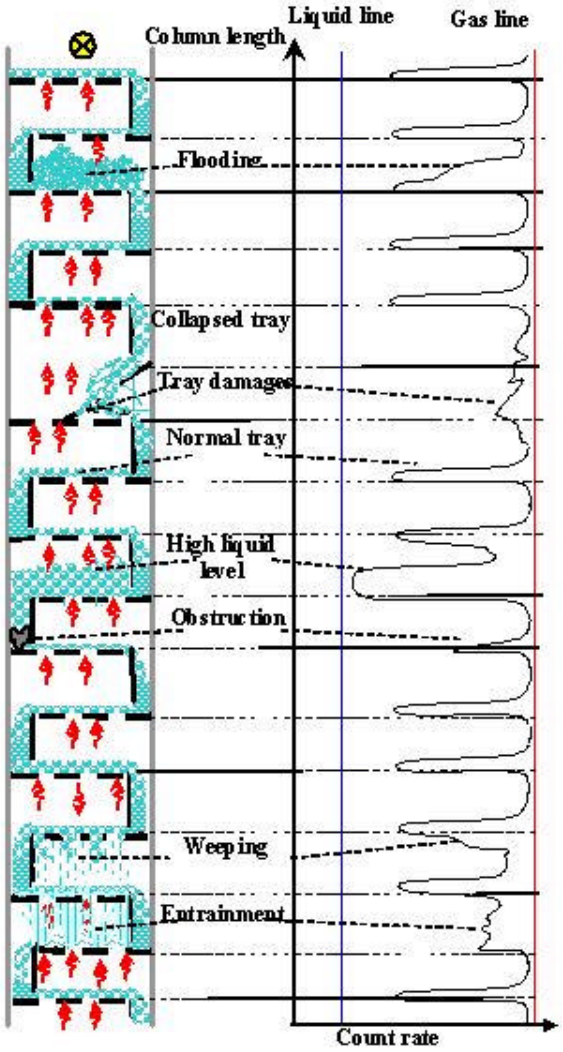

Figure 2. Scanning profile of a distillation column.

4. CONCLUSIONS

The following conclusions were reached by analysis of the gamma scan procedures, in petrochemical and chemical companies by TRICOM and IPEN/CNEN-SP in Brazil:

a. Gamma scan procedure is a nondestructive testing and a small subset of the many applications of radioisotope technology find out in petrochemical and chemical companies. The technique is straightforward, quick, sensitive, unambiguous and safe;

b. The results of the gamma scanning can be immediately discussed with process engineers, whose has always taken actions to optimize the columns performance;

c. An appropriate storage facility is necessary when the radioactive sealed sources need to be stored in safety and security place, when they are not been used for gamma scanning experiments; and

d. The individual effective dose for the inspection group, after each gamma scan procedure has not exceed the permissible limits recommended by the regulatory authority, Brazilian Nuclear Energy Commission - CNEN.

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